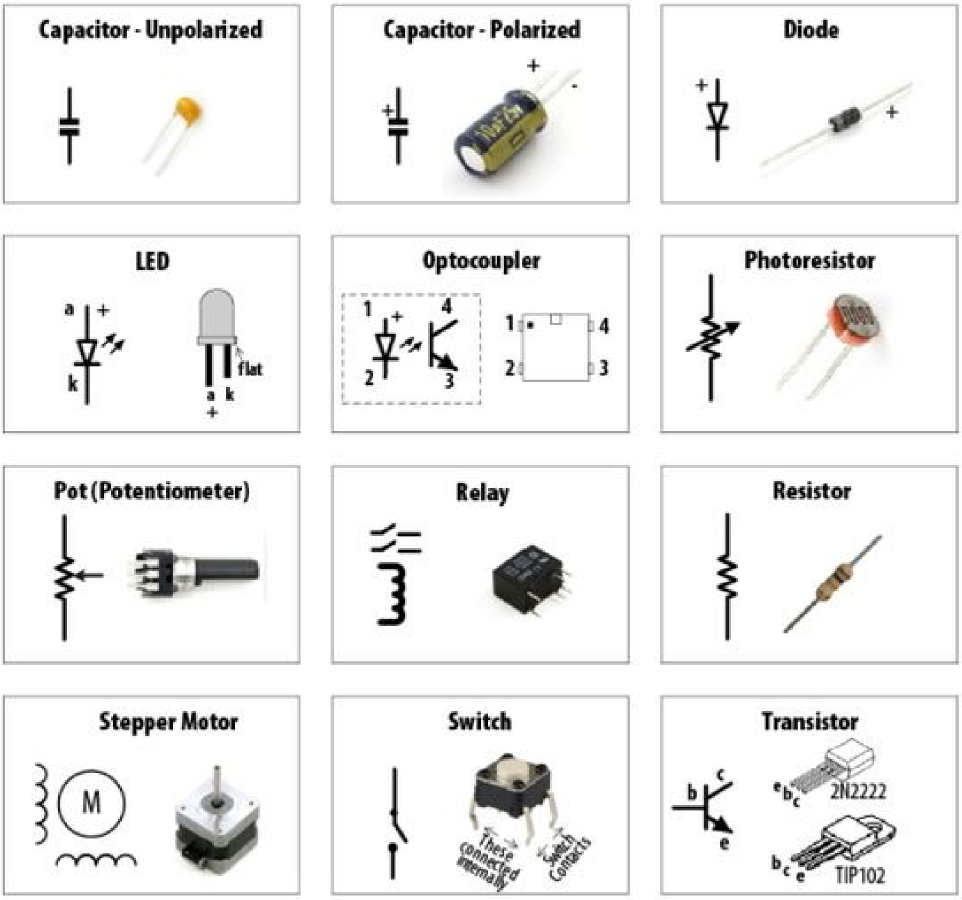
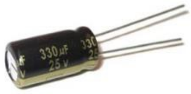
Information:
- Common Electrical Components
- Resistor Chart and Capacitors Codes
- Breadboards and some simple wiring layouts
- Using a Multimeter
- Series and Parallel Resistor Formulas
- Wheatstone Bridge Formulas

Some History: While analog devices have been supplanted by their digital equivalents in many applications, they are still widely used and remain engrained in engineered devices. An analog output format is often ergonomically superior in monitoring, as evidenced by modern car speedometer dials and dial wristwatches. Too often we qualify a digital device by its digital readout, but internal analog circuits form the foundation for both analog and many digital indicating systems. In fact, many of the systems that we interface with are analog and digital hybrids. Within a signal chain, it is common to find digital and analog electrical devices being used together and so requiring special signal conditioning. An understanding of analog device function provides insight, as well as a historical reference point, into the advantages and disadvantages of digital counterparts.

Common Electrical Components



Capacitors (passive electrical elements)

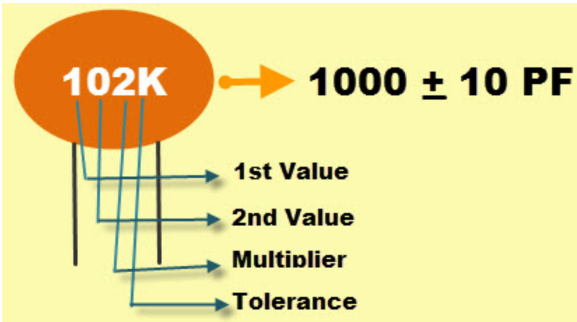


Polarized Capacitor

Non-polarized Capacitor

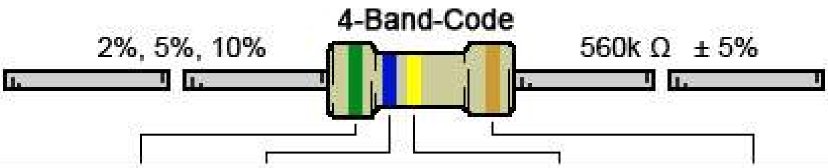
Capacitor Codes

Code	Tolerance	Code	Tolerance
A	± 0.05 pF	K	± 10 %
B	± 0.1 pF	L	± 15 %
C	± 0.25 pF	M	± 20 %
D	± 0.5 pF	N	± 30 %
E	± 0.5 %	P	-0 to 100 %
F	± 1 %	S	-20 to 50 %
G	± 2 %	W	-0 to 200 %
H	± 3 %	X	-20 to 40 %
J	± 5 %	Z	-20 to 80 %

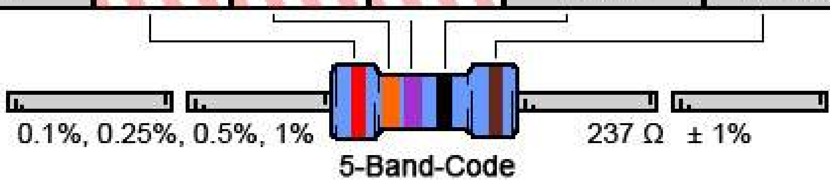


Resistors

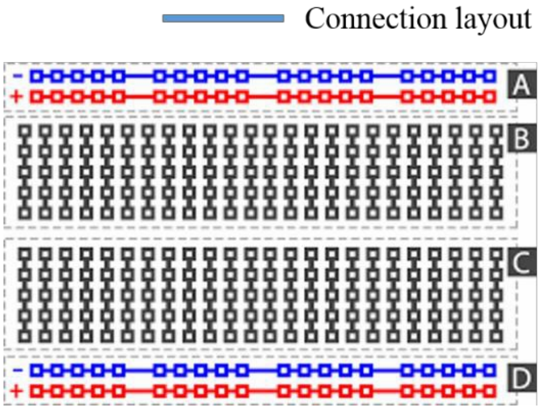
Resistor Chart

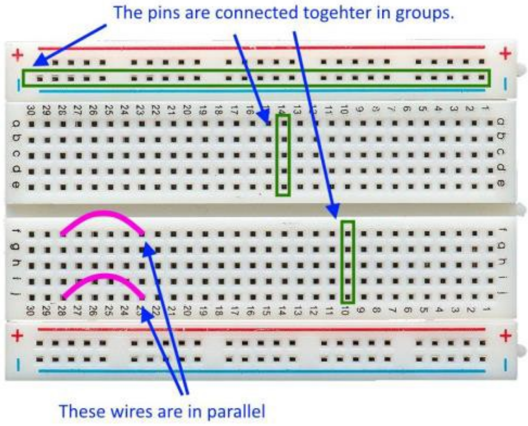


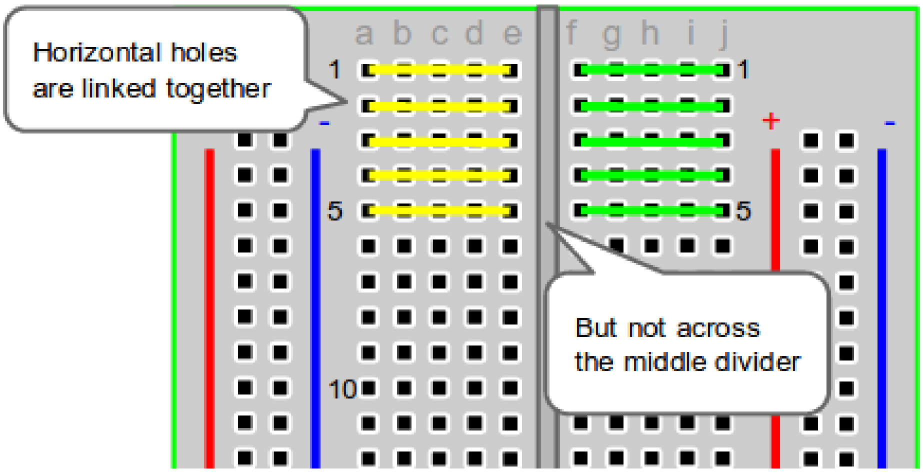
COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)



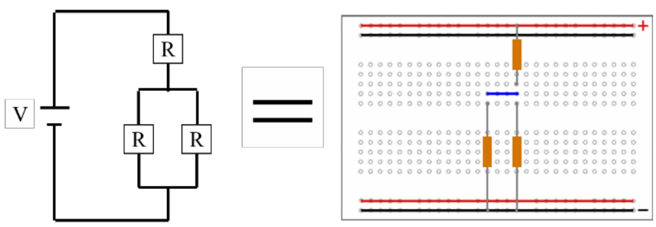
Breadboard: Pin diagram

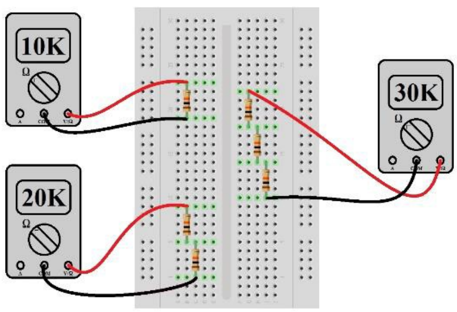






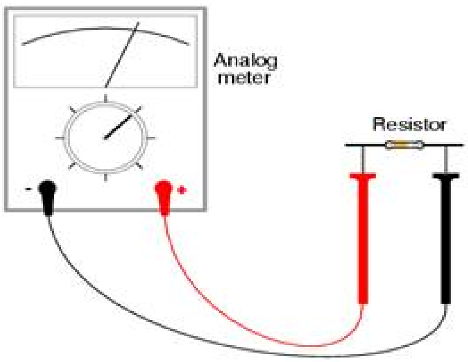
Breadboard Layouts: 2 examples





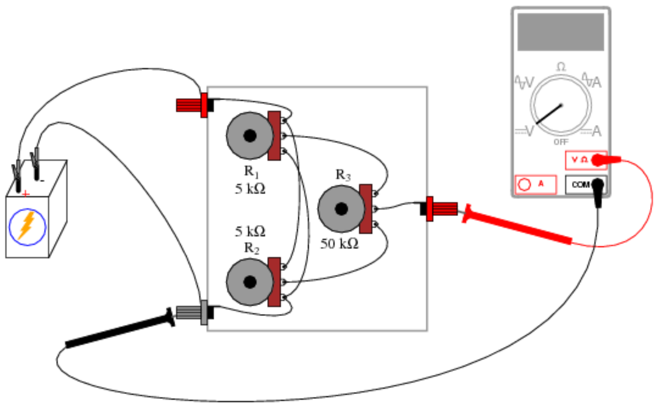
Taking Measurements with a Digital Multimeter

STUDY YOUR USER MANUAL!



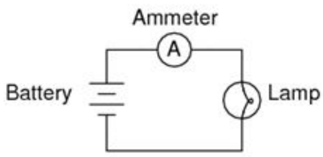
Measuring Resistance

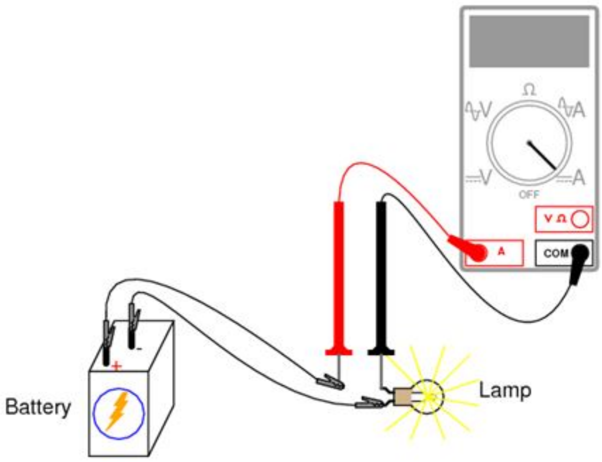
- Doesn't require a power source
- Can measure outside of a circuit
- If you are detecting resistance in a circuit, be sure to have the power supply OFF



Measuring Voltage

- Just probe the existing circuit.
- The meter is NOT part of the circuit

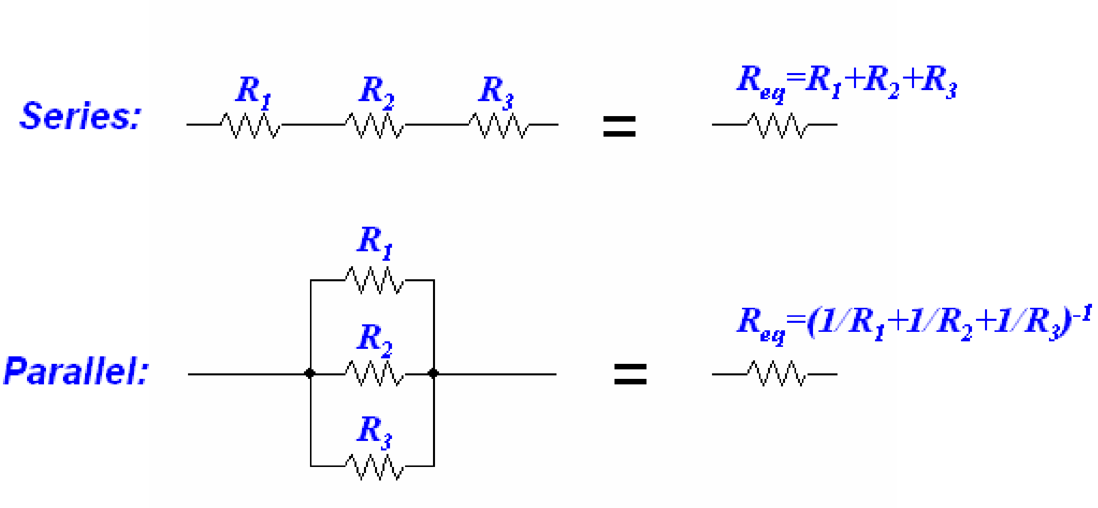




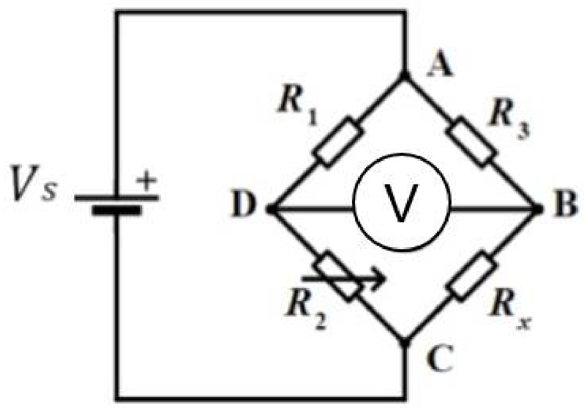
Measuring Current

- MUST have meter as part of the circuit
- The wiring of the circuit MUST be altered
- Allow the meter to be placed in series in the circuit at the point where the current is to be measured

Useful Formulas



Wheatstone Bridge – the setup shown is for detecting an unknown resistance value, Rx. The R2 is a variable resistor that is used to balance the bridge.



$$\frac{R_x}{R_3} = \frac{R_2}{R_1}$$

$$R_x = R_3 \frac{R_2}{R_1}$$

$$V = \left(\frac{R_1}{R_1 + R_2} - \frac{R_x}{R_x + R_3}\right) V_S$$

Revisit your Circuit course notes 😊 or check out some of the useful links on next page.

Useful links for more information

Voltage Dividers
https://learn.sparkfun.com/tutorials/voltage-dividers/all

Wheatstone Bridge
https://www.electronics-tutorials.ws/blog/wheatstone-bridge.html

https://www.grc.nasa.gov/www/k-12/airplane/tunwheat.html

Resistance
https://opentextbc.ca/physicstestbook2/chapter/resistors-in-series-and-parallel/

Capacitors
https://www.wikihow.com/Read-a-Capacitor

https://learn.sparkfun.com/tutorials/polarity/all